

# DESIGN OF POWER CONTROL UNIT FOR HEAT RECOVERY DEVICE USED IN RENEWABLE ENERGY SYSTEM

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**Abstract**-Heat recovery devices are used for saving energy especially for the renewable energy systems because of effective usage of electrical energy while providing air conditioning in spaces which needs fresh air. These devices pay back installation costs by saving energy in a short period. In terms of energy recovery, it is very important to design the power control panels which controls the fan and heater level of the heat recovery devices. In this paper, a power control unit which controlling the heat recovery unit has been designed. The heat recovery units and control panels have been studied and a power control unit controlling of fan and temperature has been developed. In design and simulation works, using by Proteus pressed circuit card development program and microcontroller based PIC-C program as hardware and software of the unit has been developed.

**Keywords:** Heat recovery units, power control unit, control with microcontroller.

## I. INTRODUCTION

Heat recovery units are devices which basically transfer temporal energy of exhaust gas to fresh air and in this way arrange of fresh air in respect to heating and cooling and consist of electronic and mechanical components. At the same time, these devices have filtering features and clean of air inside [1].

Heat recovery theory has especially increasing interest and also importance in recent years. In Europe, 40% of total consumed energy is the energy used up in buildings. In the world, quick increases of human population simultaneously increase of necessary number of building for sheltering. Therefore, optimizing of energy consumption have been gaining importance. For this reason, heat recovery has been performed by using air to air heat exchanger for increasing efficiency of heating-cooling and air quality of room in the building air condition systems and at the same time relieving of consumer economy [1].

Recently, for air conditioning system, necessities of heat recovery units have been highly accepted in European Countries and they have also gained importance in Turkey. In new buildings which have air conditioning systems especially for air condition flow 500 m<sup>3</sup>/h and more, using of heat recovery units are provided 50% of efficiency, has been made mandatory [1].

Most of the renewable energy systems are the power generation systems producing limited electrical energy.

For this reason, the devices and equipments connected to these power generation systems as a load must be an energy saving loads. One of these loads is the energy saving heat recovery devices.

In this research work, first literature survey has been conducted and similar studies have been investigated. Accordingly, it is decided to design a power control unit for air to air heat recovery devices which are the most extensive area of usage. The basic power electronic devices in the market have been investigated to identify the most appropriate elements for technical aspects. Then, a power control unit for fan and temperature controlling has been designed and constructed by using power control panel which provides remote control for heat recovery device. In order to confirm the design, two subprograms of the Proteus program, „Isis“ for electronic circuit schematic drawing and „Ares“ for printed circuit board drawing, have been used. The software of the power control unit has been developed by using a CCS PIC-C Customer Computer Services Company's C programming language compiler developed for PIC micro controllers. Finally, required testing process of the designed unit has been completed for mass production [2].

For this purpose, the present work has been organized as first the heat recovery system's theory, basic structures and varieties. Then, the design aspects have been explained for a power control part of a heat recovery unit to control fan and heater. It is essential to provide the adjustment of heater level and also to operate the alarm signal when fire occurs and to check the aspirator. Finally, the design and test results have been discussed in detail..

## II. HEAT RECOVERY UNITS

Heat recovery units are the devices which basically transfer temporal energy of exhaust gas to fresh air, and in this way the fresh air is arranged in respect to heating and cooling. Consequently, it consists of electronic and mechanical components for this purpose. In addition, these devices have filtering features and clean the air inside.

Heat recovery units have many profits and advantages to environment and also to national economy.

### A. Working Principal of Heat Recovery Units

Heat recovery units recover heat energy by using available heat of exhaust gas for heating clean air and in this way, save energy without mixing exhaust gas and

clean air thanks to fan and exchanger with special plate. The figure of typical heat recovery units is shown in Figure 1 [3].



Figure 1. Heat recovery unit

### B. Water to Water Heat Recovery Units

Waste is transferred from heat source to cold source and several heat exchanger are used. Recently, systems including heat pipe, run around coil and heat exchanger has been replaced with cross flow heat exchanger which is more efficient [3]. Mechanical diagram of typical water to water heat recovery unit is shown in Figure 2 [3].

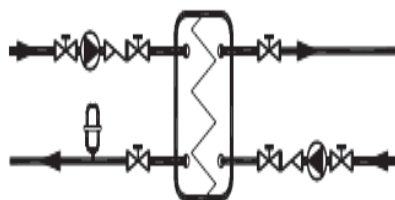


Figure 2. Water to water heat recovery unit

### C. Air to Air Heat Recovery Units

The importance of air to air heat recovery units have been increased with increase in energy consumption. Especially, so much energy saving has been performed by recovering heat from exhausted air. Diagram of air to air heat recovery unit is shown in Figure 3 [3].

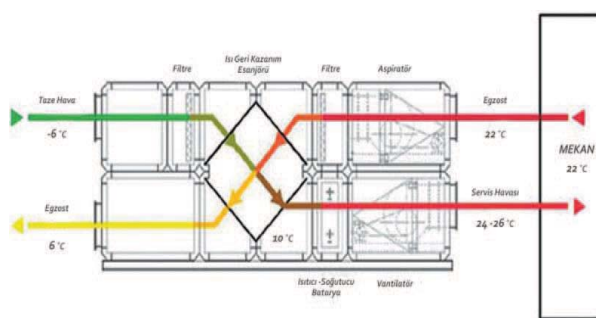


Figure 3. Air to air heat recovery unit

### D. Power Control Unit for Heat Recovery Units

Control units controlling power of heat recovery units have been developed. In this paper, a power control unit for a heat recovery unit has been developed. This developed power control unit is described in next section of this paper.

## III. APPLICATION

In this paper, a power control unit for a heat recovery unit which controls fan and heater, provides alignment of degree of heater, also produces alarm signal when fire and checks if aspirator and ventilator is clean or dirty has been designed and produced.

### A. Designed Circuits

For this purpose, an electronic circuit card has been designed and produced. The electronic circuit card consists of nine different electronic card whose names are mentioned below. They are connected with each other and all of them are located on one pressed circuit card. These circuits have been designed with the help of Ares (Electronics circuit design programme) section of Proteus (Electronics circuit and card design programme).

The name of designed circuits:

- PIC 18F26K20 mikrocontroller circuit,
- Regulator circuit,
- Temperature circuit,
- Heat control circuit,
- Communication circuit,
- AC/DC converter circuit,
- Digital input circuit,
- Triac control circuit,
- In Circuit Serial Programming (ICSP) circuit.

The function of the circuits is described below:

PIC 18F26K20 mikrocontroller circuit: Controlling digitally of other circuits,

Regulator circuit: Producing 5 V DC from 220 V AC

Temperature circuit: Measuring temperature,

Heat control circuit: ON-OFF controlling for heater by relay,

Communication circuit: Providing communication between mikrocontroller and temperature, fan and heater,

AC/DC converter circuit: Converting 220V AC to 24V AC and obtaining 24 V DC output by bridge diod connected to output of transformer,

Digital input circuit: Sensing any 3 of information such as fan flow data, fire input, high temperature input in Building Management System (BMS) ,

Triac control circuit: Controlling of speed of single phase AC fan used in the system,

In Circuit Serial Programming (ICSP) circuit: When programming or coding of mikrocontroller, instead of removing and installing it in each time, programming when mikrocontroller is on circuit with the help of an interface cable.

### B. PIC18F26K20 Mikrocontroller Circuit

For the purpose of controlling digitally of other circuits, a mikrocontroller is used and pin diagram of the mikrocontroller is shown in Figure 4.

By PIC18F26K20 mikrocontroller, devices below can be controlled:

- Relay,
- Triac,
- Communication,
- Digital input and output,
- Temperature sensor.

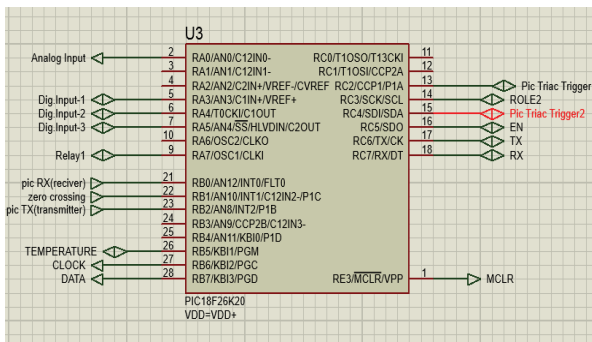


Figure 4. Pin diagram of PIC18F26K20 mikrocontroller

**C. Software**

For the purpose of controlling of designed circuits, a software in CCS PIC-C programme and C programming language has been developed. CCS PIC-C programme screen for writing instruction is shown in Figure 5 and toolbar menu is shown in Figure 6.

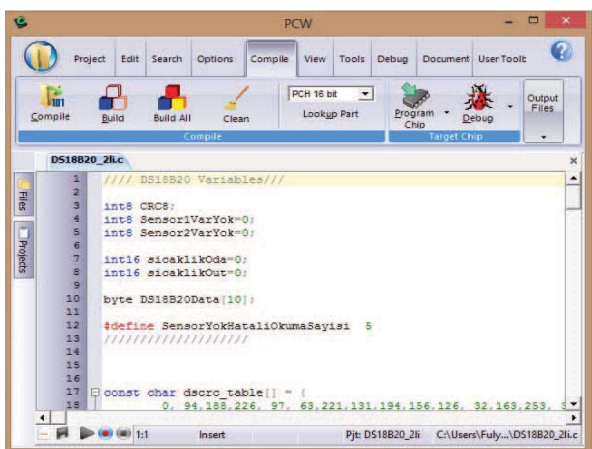


Figure 5. CCS PIC-C the screen for writing instruction

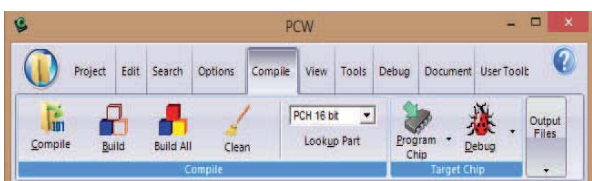


Figure 6. Toolbar menu

**D. User Manual for Power Control Unit for Heat Recovery Unit**

Circuit card of power control unit for heat recovery unit is shown in Figure 7, and a control panel is shown in Figure 8. For working of power control unit for heat recovery unit, these steps should be followed:

1) First of all, for testing if power control unit is working or not, 50 W bulb should be installed to output of control card. The bulb should be installed to control card of digital inputs. In addition, external temperature sensor should be installed.

2) If external room sensor is requested to be removed from circuit, the type of temperature sensor on control panel should be selected.

3) For activating heaters, on control panel, "Open Main Heater" tab should be selected and "Ok" button should be pressed.

4) Next, after selecting main heater tab; one of "On", "Off" and "Auto" position should be selected arbitrarily. For example, if "On" position is selected, according to set value adjusted between 18°C - 35°C interval, if temperature which sensor sense is below this value, heaters will work until arrive the value, after arriving the value heaters will not work.

If filter is dirty, "Filter is dirty" error writes on control panel.

If environment is in very high temperature, "High temperature" error occurs and shuts the devices.



Figure 7. Power control unit circuit card has been designed and produced



Figure 8: Power control unit control panel



#### IV. RESULTS

When designed power control unit for heat recovery devices works, following results are obtained:

When "On" button of control panel is pressed;

Ventilator (Clean air section): It is seen to adjust fan speed of clean air. Ventilator speed section consist of 10 degree from 0 to 9. For making adjustment of degree; menu button should be pressed and exhaust air fan speed tab should be selected, next, selection should be made after coming requested degree by up-down direction buttons and selection made should be confirmed by menu button.

Aspirator (Exhaust air section): Exhausted air is adjusted by fan speed degree. Aspirator speed section consist of 10 degree from 0 to 9. For making adjustment of degree;

- Menu button should be pressed,
- Exhausted air fan speed tab should be selected,
- Selection should be made after coming requested degree by up-down direction buttons,
- Selection made should be confirmed by menu button.

*Room Temperature Set Value Tab:* In environment, it is seen to be fixed in requested temperature value. Temperature can be adjusted between 5 and 30°C. For adjusting temperature; menu button should be pressed, temperature set value tab should be selected, next requested temperature should be determined by up-down direction button and it should be approved by menu button.

*Open Main Heater Tab:* "Open Main Heater" tab should be pressed and for activating the heater, "Yes" tab should be pressed. For making main heater passive, "No" tab should be pressed. In this way, temperature of environment can be in set value determined.

*Main Heater Position Tab:* In main heater position tab, "On", "Off" and "Auto" selections are seen to be available. When "On" selection pressed, main heater opens. When "Off" selection pressed main heater closes. When "Auto" selection pressed, according to the adjusted set value heater is seen to work automatically.

With designed and produced circuit card, for heat recovery devices, it is seen to control fan and speed, produce adjustment of degree of heater, in addition to produce alarm signal in case of fire and to check if aspirator and ventilator is dirty or not.

As a result of working of devices, in air conditioning systems, before energy of exhausted air coming from inside of room is wasted outside, firstly thanks to heat recovery devices, it is transferred to fresh air passing filter.

Energy of fresh air coming outside is seen to be transferred inside via fresh air air-conditioning channel by setting temperature value of power control unit for heat recovery devices thanks to heater (resistance). (Figure 9).

#### V. CONCLUSIONS

In this paper, a power control unit for a heat recovery unit used in and most cases supplied by renewable energy systems has been designed and produced.

For designing power control unit; several heat recovery devices and their working principal have been analyzed. Following, a power control unit for air to air heat recovery unit which is used and is supplied more common by renewable energy systems is decided to be designed.

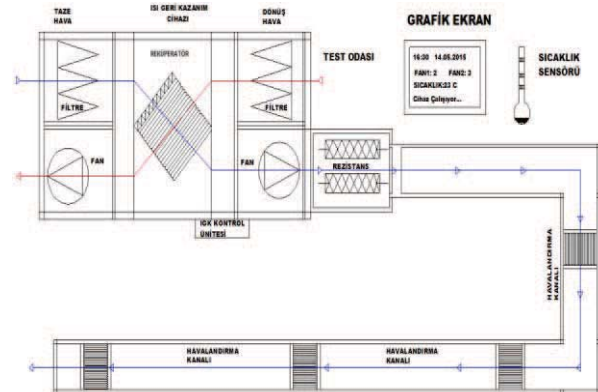


Figure 9. Flow diagram of heat recovery devices

As an application; a pressed electronic card consisting of mikrocontroller circuit, regulator circuit, temperature circuit, heat control circuit, communication circuit, AC/DC converter circuit, digital input circuit, triac control circuit, In Circuit Serial Programming (ICSP) circuit has been designed and a prototype has been produced and located within control panel. These circuits has been designed in Isis and Ares section of Proteus programme.

For the purpose of controlling developed circuits, in CCS PIC-C programme and in C programming language a software has been developed.

Thanks to designed and produced circuit card, for heat recovery devices, it is seen to control fan and heater, provide adjustment of degree of heater, in addition to produce alarm signal in case of fire and check if aspirator and ventilator is dirty or not.

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### NOMENCLATURES

*Ares* : Elektronics circuit design programme  
*BMS* : Building Management System  
*CCS* : Customer Computer Services  
*ICSP* : In Circuit Serial Programming  
*Isis* : Elektronics card design programme  
*PIC* :Programming in circuit  
*Proteus* : Elektronics circuit and card design programme

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### BIOGRAPHIES



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